Lab #2:
Astronomical Spectroscopy: Detecting light with a CCD

James. R. Graham, 2014/9/17

Of all objects, the planets are those which appear to us under the least varied aspect. We see how we may determine their forms, their distances, their bulk, and their motions, but we can never known anything of their chemical or mineralogical structure; and, much less, that of organized beings living on their surface…
Auguste Comte, The Positive Philosophy, Book II, Chapter 1 (1842)

Your report is due on Tuesday, October 14, 2013 at 5:59 PM PST.
Show & tell on 9/30 and 10/7.

1 Overview

Spectroscopy is a key tool used by astrophysicists; for example it is used to measure the chemical composition and physical conditions (temperature, pressure, and magnetic field strength) in planets, stars, and galaxies. In this lab you will use a spectrograph to collect data from common sources (room lights), establish a wavelength scale, investigate the noise properties of the detectors, and measure astronomical spectra of stars and planets.

2 Schedule

This is a three-week lab—we will discuss this material on 9/23, 9/30, & 10/7. Your lab report is due on 10/14. For "show-and-tell" on 9/30 you should have progressed through steps 1-4 and begun step number 5 (see §4 below). On 10/7, you should be prepared to discuss steps 5 and 6 in detail.

3 Goals

Use a simple, visible light (350-700 nm) spectrometer to explore the spectra of laboratory and astrophysical sources. Along the way we will measure the wavelength calibration of the spectrometer, which will introduce the concept of linear least squares. We will also characterize the noise properties of the CCD detector upon which the spectrograph is based.

3.1 Reading assignments

- USB 2000 spectrometer handout (available on the AY 120 web page).
- Complete reading the statistics handouts.
- Tutorials on least squares fitting (AY 120 web page.)
- Notes on CCD noise properties (AY 120 web page.)
- Review Chapters 1-4 "Handbook of CCD Astronomy," S. B. Howell, Cambridge University Press. There are three copies on the UG Lab bookshelf. Pay special attention to §§3.4-3.8 and §§4.2-4.3, & 4.5.
- Familiarize yourself with the contents of "To Measure the Sky," F. R. Chromey, Cambridge University Press.

4 Key steps

1. Sign the check out form so that you can retrieve the spectrometer from the storage cabinet.
2. Learn to operate the USB 2000 spectrometer using the SpectralSuite software on the iMac in the UG Lab.
3. Save spectra and read them into Python for plotting and analysis.
4. Observe spectra of common sources—incandescent lamp, fluorescent strip light, color filters, neon gas discharge lamp, and sunlight.
5. Determine the wavelength calibration of the spectrometer, i.e., the mapping between pixel number and wavelength. Do this by measuring the *centroids* (i.e., pixel positions) of bright Hg I (fluorescent room lights) and Ne I lines of known wavelength. Then use the method of linear least squares to determine a polynomial fit to these data.
6. Measure the saturation level, read noise, and gain of the CCD photon detector.
7. Write up your report.